Normal-Averaged Smoothing for Mesh Quality Improvement

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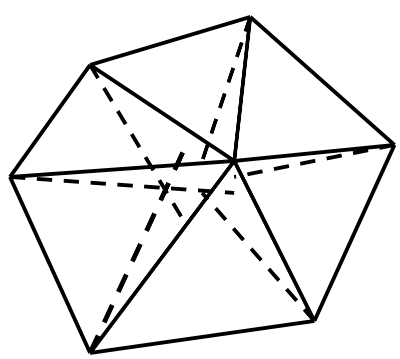
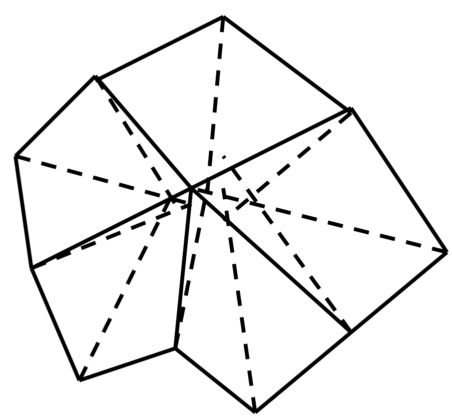
Based on consideration of the connected nodes for triangular and tetrahedral meshes and diagonal nodes for quadrilateral and hexahedral meshes additionally, a normal-averaged smoothing method is provided for improving mesh quality. This method is introduced with a generalization of the angle-based smoothing method [1].

Laplacian smoothing is popularly applied to smooth mesh nodes and enhance mesh quality, but it creates inverted elements when meshes are with concave mesh elements. Angle-based smoothing was derived in [1] and applied to triangular, quadrilateral and tri-quad mixed meshes for 2D case. No inverted element can be created with this method, but it is difficult to extend this method to 3D volume mesh. In this paper, a normal-averaged smoothing algorithm is presented. It is applied to triangular, quadrilateral, tetrahedral, hexahedral, tri-quad and tet-hex meshes. Normal-averaged smoothing is created with two steps for smoothing meshes.

1. Calculate the averaged normal project position of a node.
For triangular and tetrahedral meshes, to smoothing one node, we consider all its connected nodes and get the normal for each connected node pointing to the other nodes which share the same face with the node to smooth, the connected node, then average the normal and multiply the distance of the node to smooth and connected node.



Triangular Meshes



Quadrilateral Meshes

2. Create a new position of the node
After getting the projected positions from connected nodes and diagonal nodes (quad mesh), we add a weighted average of the position values and create the new position of the node.

The normal-averaged smoothing method has the advantages, no inverted elements can be produced for the mesh elements with the concave edge structures and it can be applied to 2D and 3D surface meshes, such as, triangular, quadrilateral and tri-quad mixed meshes and 3D volume meshes, such as, tetrahedral, hexahedral and tet-hex mixed meshes.

References

[1] T. Zhou and K. Shimada, “An Angle-Based Approach to Two-Dimensional Mesh Smoothing”, *Proc. 9th Intl. Meshing Roundtable, Sandia National Laboratories, p449-457, 1998*